ALASKA SEA ENERGY: A GUIDE FOR HYDROPONIC DEVELOPMENT

By

Daniel Blair-Madrid, B.T.

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APPROVED:
Charlene Stern, Committee Chair
Jessica Black, Committee Member
Will Hutto, Committee Member
Jessica Black, Department Chair
Department of Rural Development

ABSTRACT

This guide has been created to help those unfamiliar with the benefits of growing food with hydroponics to gain a deeper understanding of how such techniques can help rural communities with issues of food sovereignty and provide healthy fresh food through every season. It also includes input from communities participating in the project. Rural coastal communities in particular have a unique opportunity of combining both hydroponic techniques and ocean-based fertilization to maximize sustainable food production, thereby reducing reliance on imported food. The instructions contained within this guide will describe various types of hydroponic systems, recommendations for equipment, and how to address challenges that can arise from each system. Each system may have certain advantages and disadvantages depending upon the needs of the grower.

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Acknowledgments

I wanted to give a special thanks to Mark Wright who managed the Institute of Arctic Biology greenhouse during my experiments and was a valuable resource in helping to design a suitable experiment to provide publishable data. A special thanks also to Jennifer Humphrey for her help with one of the experiments at the greenhouse and her contribution in analyzing the results. I would also like to express my appreciation to Lawrence Duffy for his advice in association with the Resilience Adaptation Program.

In loving memory of my abuela, she passed during my time here at the University of Alaska Fairbanks and will always be in my heart.

Introduction

This guide has been created to help those unfamiliar with the benefits of growing food with hydroponics to gain a deeper understanding of how such techniques can help rural communities with issues of food sovereignty and provide healthy fresh food through every season. It also includes input from communities participating in the project. Rural coastal communities in particular have a unique opportunity of combining both hydroponic techniques and ocean-based fertilization to maximize sustainable food production, thereby reducing reliance on imported food. The instructions contained within this guide will describe various types of hydroponic systems, recommendations for equipment, and how to address challenges that can arise from each system. Each system may have certain advantages and disadvantages depending upon the needs of the grower.

The research that was conducted in support of this guide was inspired by Charles Walters book, *Fertility from The Ocean Deep: Nature's Perfect Nutrient Blend for The Farm*, as well as experiments performed by Dr. Maynard Murray. A biochemist, research scientist, and medical doctor, Dr. Murray graduated from the Cincinnati College of Medicine and subsequently published, *Sea Energy Agriculture* (1976). He found that ocean solids offer 90 minerals and trace elements, stating that a plant can grow to maturity and yet make dangerous substitutions of elements in its structure due to the chemical attempts to compensate for an imbalance of the proper elements in the soil. If cells, in turn, must compensate for the dilution or lack of elements, they lose their resistance to diseases present or attract diseases and insects. Further, "food and other crops require an average of 40 elements from the soil." (Murray, 1976, p.69). In contrast, commercial fertilizers on average add only three to six elements to the soil. This is why trace mineral supplementation is so important, because when plants receive full nutrition, they are healthier which in turn supports healthier food for communities.

The Law of the Minimum reinforces this concept by stating that, yield is proportional to the amount of the most limiting nutrient. (Barak, 2000). Murray theorized that the most efficient method to re-mineralize soils (to ensure that the food produced by them is at their optimal mineral composition) is to recycle the elements lost to the sea back into the land. It was at this point that the concept of Sea Energy Agriculture was introduced. Murray would go on to conduct extensive agricultural research trials over a 30-year period. These trials focused on the soil/root route of plant to animal nutrition. In his initial greenhouse experiments, Murray used high quality seawater collected by the U.S. Navy three miles offshore of the Atlantic Ocean. He poured small amounts of seawater onto soil and determined that the 3.5 percent mineral solids in the seawater had a profoundly positive effect on plant growth and development.

It is my hope that others will see value in using the ocean as a fertilization source in hydroponics and conduct experiments to further refine methodologies in support of sustainable development of rural communities. Hydroponics is a way of growing food without soil that has been in existence for thousands of years in one form or another. Hydroponic systems have undergone serious advancements over time. With the aid of new technologies, modern hydroponic systems have become fully automated including some that even utilize artificial intelligence. For example, software now exists which takes digital photos of major crops plagued with common ailments and uses an algorithm to recognize diseases and offer recommended treatment strategies (Berhmann, 2019). Additionally, growers are able to use specialized equipment to adjust humidity, temperature, and irrigation through a process of trial and error before they find the right mix for an optimal growing environment.

Terminology

The following are terms used in the field of hydroponics that will be helpful for the reader to be familiar with.

Chinampa (floating technique): Originally used in ancient Mesoamerica, Chinampa is a passive system that utilized natural lake environments or sophisticated water control infrastructure, by floating woven reeds that plants would grow on top of.

Nutrient Film Technique (NFT): An active system (meaning that it is reliant on moving parts), that continuously pumps nutrient water up from a reservoir to plants in such a way that allows gravity to recycle the unused water back into the reservoir.

Ebb and Flow: An active system that fills a shallow flood tray from underneath with a pump from a reservoir at timed intervals, that drains by gravity back into the reservoir after soaking plant roots.

Deep Water Culture (DWC): Systems can be either active or passive and is similar to the floating technique. Plants can be grown faster with an air pump to oxygenate reservoir(s). Allows for larger plants to be grown with buckets.

Wick: A passive system that draws nutrients up to the roots from a reservoir via capillary action. Wicks can be made from various types of materials such as cotton, hemp, or nylon.

Media: Materials used to help plant roots support the weight of a growing plant and maintain a good water/oxygen ratio. Many different types of materials can be considered media in this context such as rockwool, coco coir (fiber from the coconut husk), expanded clay, perlite, vermiculite, stones, recycled glass, etc.

History of Hydroponics

The word "hydroponic" is derived from the Greek words "hydro" (meaning water) and "ponos" (meaning labor or work). The term hydroponics was first introduced in 1937 by William Frederick Gericke (UC Berkeley, 2015). Some of the earliest examples of hydroponics comes from ancient Babylon, although there has been no archaeological evidence found to date. One theory suggests that such gardens existed in Nineveh, based on the writings of King Sennacherib who ruled from 704-681 BCE (Fenollós, 2020). Other theories suggest that hydroponics may have been practiced in ancient Egypt based on hieroglyphic evidence. However, throughout Mesoamerica (historical and cultural regions of North and Central America), there has been a long history of hydroponic use that extends to the modern day (Hirst, 2019). Chinampas (see Figure 1) being one of the more prevalent techniques, shows evidence of its use dating back at least as early as 1250 CE.

Figure 1: Artist depiction of chinampas being used.

Source: Dhwty (2014).

Some of the most compelling evidence for the earliest use of hydroponics comes from central Guatemala where the Mayan settlements of Tikal and Yax Mutal were built with traces of early agriculture dating as far back as 1000 BCE (Webster, 2002). A series of dams and reservoirs in Tikal indicate that the Maya used to direct water with a rudimentary, yet effective, sand-based water filtration

Figure 2: Rendering of Tikal collection/diversion system. Source: National Geographic Society. n.d.

system (see Figure 2). Water from reservoirs without filters was most likely used for agriculture (Slivka, 2012). The reservoirs were built out of the same rock quarries used to supply stones for their temples. The holes left in the ground after the removal of stones were perfect for filling with water. They also sealed off all cracks and crevasses in their walkways and buildings with plaster thereby funneling every possible drop of rain water in Tikal to the reservoirs. The reservoirs were placed on different tiers of elevation so that they could use gravity to direct the water as needed throughout the settlement.

Food Sovereignty

Having more coastline in Alaska than the rest of the country combined, this project shows the opportunity for developing quality fertilizer from hydroponics that can be used in crop production and potentially benefit rural communities by helping meet their need for more fresh produce. Through a series of greenhouse experiments, the viability of ocean water as a supplement for plant growth has been established. The use of ocean water combined with the efficiency of hydroponics in crop production can be used to increase the resilience of rural communities facing food insecurity.

The term "food sovereignty" was coined in 1996 by members of an international farmers' organization known as La Vía Campesina. They asserted that people who produce, distribute, and consume food should control the mechanisms and policies of food production and distribution (Food First News & Views, 2005). The idea of sovereignty however is nothing new. The concept spans thousands of years and existed in many places across the world. Though there are different definitions, they generally share a basic understanding that food sovereignty allows for a person/peoples to have greater self-determination and control over their food systems. This is especially meaningful in Alaska where there are over 200 federally-recognized tribal governments who are in real time assessing and promoting their food sovereignty to meet the needs of their tribal citizens.

According to the Alaska Food Policy Council, "food security is a phenomenon of health, safety, tradition, community, environment, economy, culture." It also relates to the control people have over their food supply, how much voice they have in what and how that food is grown, how it is harvested and prepared, how it is regulated, sold, and marketed (AFPC, 2018). The Inuit Circumpolar Council (ICC) defines "food sovereignty" as the right for Alaska Inuit to define their own hunting, gathering, fishing, land, and water policies. According to ICC, "It's the right to define what is sustainably, socially, economically, and culturally appropriate for the distribution of food and also to maintain ecological health. And this is deeper than that; it speaks directly to our cultural identity and our relationship that we have with the land, the water, to our whole environment" (ICC, 2017). Such definitions highlight the importance of food security and sovereignty in the context of Alaska and the importance of the environment to achieving this aspiration. After all, what good is food sovereignty if the environment is not healthy enough to yield food?

Ocean Water in Hydroponics

People around the world have looked to the ocean as an alternative irrigation input for crops with the primary driver being water conservation (Maria Lucia D'Amico, et al., 2004). Dehydrated ocean water has shown promise in providing plants with trace minerals for enhanced growth. In small amounts, salt (or sodium chloride) is a necessary component for all life. It should be noted that there are many different types of salt, each with different chemical compositions and properties. The tastes of these salts vary based on their chemical composition (University of Hawaiʻi, 2020). Salt has been produced from the evaporation of seawater since prehistoric times and contains most of the essential macro- and micro minerals essential for healthy plant growth. Investigation into the use of seawater for irrigation in agriculture has been ongoing for decades. Diluted seawater (DSW) is a simple yet vital input used in natural farming as a source of mineral nutrition for the production of a variety of fruit and vegetable crops, as well as for lawns, pastures, and flowers (Miller, et al., 2013). This makes a promising case for why an ocean-based fertilizer would be a great asset for rural coastal communities to both produce and use in their own crops.

Turning ocean water into sea salt is a relatively simple process with an end product that has a wide range of uses. The ocean is vitally important to most cultures in the world. The salts themselves are one of the keys to life and as essential as water or sunlight. Salt used to be (and in some cases, still is) exchanged as currency. It is no coincidence that the etymology of the word "salary" includes 'sal' (the latin word for salt). Ghandi won India's independence by "illegally" (according to the British) producing sea salt.[1] There are many uses for the salts from the ocean ranging from food seasoning, to beauty products, detergents, preservatives, and fertilizer among others.

Traditionally, salt has been harvested from either solar evaporation ponds or rock deposits. Salt evaporation ponds are generally shallow, artificial basins designed to extract salt from seawater, salty lakes, or mineral-rich springs through natural evaporation. As the water dries up, the salt crystals are harvested by raking them out.[2] It

1 Caroline Lee Schwenz, "Gandhi's Salt March to Dandi" *DMS2,* 2017

2 Exploring Our Fluid Earth, "Traditional Ways of Knowing: Salt Harvesting" *TSI,* Retrieved from https://manoa.hawaii.edu/exploringourfluidearth/chemical/chemistry-and-seawater/salty-sea/

should be noted that there are areas where natural basins occur which are naturally suited for salt extraction. My personal process for extracting salts from seawater is different from such traditional methods. I harvest the seawater directly from the ocean at a depth of approximately 1.5 meters and let it evaporate in a containment vessel by way of solar radiation (within a greenhouse environment). The crystals (solids) are then extracted by hand.

The time that it takes for seawater to evaporate is dependent on several factors including how much seawater is being dried at a time, what type of environment the seawater is being dried in, and the weather in general. Such factors contribute to the variability of time needed to be able to extract the salt crystals. The process can be expedited by warmer, low humidity environments as well as the type of container used. Metal containers should be avoided as they will become oxidized and eventually rust. Other darkened materials can be used to absorb heat and while it is possible to boil the water, I cannot attest to the similarities or differences of the chemical properties of ocean salts that have been boiled versus those that have been dehydrated. Certainly there would be a reduction in microorganisms which may possibly decrease the effectiveness of the solids being used as a fertilizer in crop production.

An elemental analysis performed of Kachemak Bay in 1977 by the National Oceanic and Atmospheric Administration (NOAA) found that there are at least nine different elements essential to plant growth within the water (See Appendix A). Based on their data, the specific elements that I was able to identify included: Iron, Nickel, Copper, Zinc, Nitrogen, Magnesium, Calcium, Potassium, and Manganese (which was the most abundant). These elements still exist within the waters of Kachemak Bay, as well as within Peterson Bay and Bishop's Beach where I collected samples. This is achieved through solubility equilibrium.[3] While collecting samples I also took measurements of potential hydrogen (pH) and salinity of both areas and discovered that there was some uniformity. A pH of 8.07 was recorded for Peterson Bay and 7.95 for

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traditional-ways-knowing-salt-harvesting, Accessed 2018

3 American Chemical Society, "Ocean Chemistry" *ACS,* Retrieved from https://www.acs.org/content/acs/en/climatescience/oceansicerocks/oceanchemistry.html, Accessed 2018

Bishop's Beach showing that they are in the range of alkaline. As for the salinity, measurements of 28.6 parts per thousand (ppt) and 29.9ppt (see Figure 3), were observed respectively. In contrast, the average salinity of the ocean is 35ppt.[4]

In order to compare the data obtained by NOAA with my own, I used an independent laboratory, Brookside Laboratories, to process some of the samples collected using an "X003" test package for fertigation or hydroponic purposes. This package included analysis data on pH, Conductivity, Chloride, Nitrate, Ammonium, Sulfate, Phosphorous, Calcium, Magnesium, Sodium, Boron, Iron, Manganese, Copper, Zinc, Aluminum, Molybdenum, and Cobalt.[5] All of these are beneficial to plant health, however manganese was the most abundant element sampled by NOAA. Manganese not only plays an important role in photosynthesis and carbohydrates synthesis, but also causes the activation of more than 35 different enzymes. It also plays a role in chlorophyll production and its presence is essential in cell division and plant growth.[6] Of the samples that I had tested, magnesium was the most abundant. This element is also vital to the health of a plant and plays a major role in photosynthesis as a building block of chlorophyll in plant tissue.

Figure 3: Testing salinity at Bishop's Beach.

Having established that solids derived from seawater can enhance fertilizer for the benefit of plant growth, we can now address the benefits of hydroponics. With hydroponics, inert materials are mainly used as a supportive structure for the plants

4 University of Rhode Island, "Estuarine Science" *EPA,* Retrieved from http://omp.gso.uri.edu/ompweb/doee/science/physical/chsal1.htm, Accessed 2018
5 Brookside Laboratories, Inc., "Fertigation Analysis" *X003,* Retrieved from https://www.blinc.com/node/9, Accessed 2018
6 Mousavi, Sayed Roholla & Shahsavari, Mahmood & Rezaei, Maryam. (2011). A General Overview On Manganese (Mn) Importance For Crops Production. Australian Journal of Basic and Applied Sciences. 5. 1799-1803.

themselves. This means that there are essentially no nutritive inputs by the growth media itself (as there would be with soil). The plant therefore is reliant on the irrigation or reservoir water to obtain the nutrients needed for healthy growth. Since life on earth began in the oceans it is no surprise that terrestrial plants (descendants of aquatic plants[7]), would be able to utilize this natural irrigation input for their benefit.[8]

In a 1998 article of *Scientific American*, it was argued that seawater agriculture is not exempt from problems (such as potential salt buildup in the water tables underneath fields), however it does have several advantages. First, coastal desert farms on sandy soils generally have unimpeded drainage back to the sea. Fields have been continuously irrigated with the same seawater for over 10 years with no buildup of water or salts in the root zone. Second, coastal and inland salt desert aquifers often already have elevated concentrations of salt and so should not be damaged by seawater. Third, the salt-affected soils proposed for seawater agriculture are often barren, so installing a seawater farm may have far less effect on sensitive ecosystems than conventional agriculture does (Glenn, 1998). The previous points highlight why coastal communities are in a unique position to be able to benefit from these advantages that seawater agriculture can offer. To reiterate, coastal communities are able process seawater easier due to their location in proximity to the ocean and growing crops with seawater near the ocean can be better for the environment than soil-based traditional farming due to less potential damage from runoff.

7 Penn State, “Plants – Evolution and Diversity” Retrieved from https://wikispaces.psu.edu/display/bio110/Plants+I+-+Evolution+and+Diversity, 2012
8 Jennifer Welsh, “Complex Life Emerged from Sea Earlier Than Thought” *Live Science,* 2011

Hydroponic Design – Getting Started

When it comes to the design and implementation of a hydroponic system, the potential is limitless. The only real constraints are the environment in which the system will operate in and the needs of those that it is intended to provide for. Cost is another factor to account for and depending on design choices, may vary a lot. Using recycled or refurbished equipment can help drive costs down as can establishing good relationships with local suppliers. It is even possible to build a system for free. Hydroponics offers a way to produce plants without the need for soil and uses up to ten times less water than traditional soil-based farming.[9] It accomplishes this by containing all of the water to be used in a closed circulatory system (rather than watering open crops where water is potentially leached away to other undesired areas). Deep Water Culture (DWC) is a technique that highlights this principle by suspending the plant roots in oxygenated water, allowing for easier maintenance with regard to watering schedules. DWC offers the potential for plants to grow much faster than in the soil.[10] The example shown in figure 4 is of a hydroponic system that can be used to grow a large variety of plants and that can be easily expanded to meet the needs of high yield harvests. This design could be made even simpler by having the plants float on top of a large pool of water which would not require a pump. Such systems can also be built vertically to accommodate for space requirements. One challenge with hydroponics systems are leaks. This can be overcome by using rubber grommets and

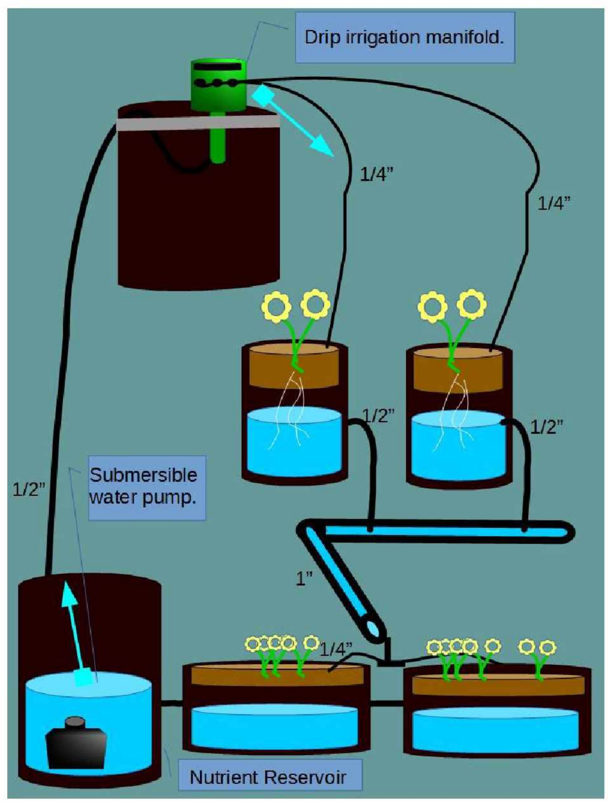


Figure 4: Custom Deep Water Culture System

9 Brandon Merrill, “More ways to save water with hydroponics” *University of Arizona,* 2011
10 Kevin Espiritu, “Deep Water Culture (DWC): What Is It And How To Get Started” *Epic Gardening*, 2017

silicone in areas that are prone to leaking such as drainage holes. Another challenge is energy costs which are especially high in rural areas. Pumps draw relatively low wattage (typically 15-25W depending on the size) however other equipment such as lights can draw upwards of 1kW or more. This is why many have turned to technologies such as LEDs (Light Emitting Diodes) which drastically reduce the amount of wattage and maintenance involved. LEDs have a come a long way since they were first introduced in the 1970s with many advancements designed specifically with plant growth in mind.[11]This is accomplished by designing bulbs that operate at specific wavelengths known to be used by plants through photosynthesis.

There are many different types of hydroponic designs and each has their own set of advantages. The variances mainly relate to how the nutrients will reach the plants (being top or bottom fed) and how those nutrients are drained. Systems can range from simply draining to waste, to being recycled into other plants for further uptake. The more advanced techniques allow for vertical growing which is ideal for spaces where room width is limited or spaces that may otherwise go unused. Figure 5 highlights the ability to recycle nutrient water.

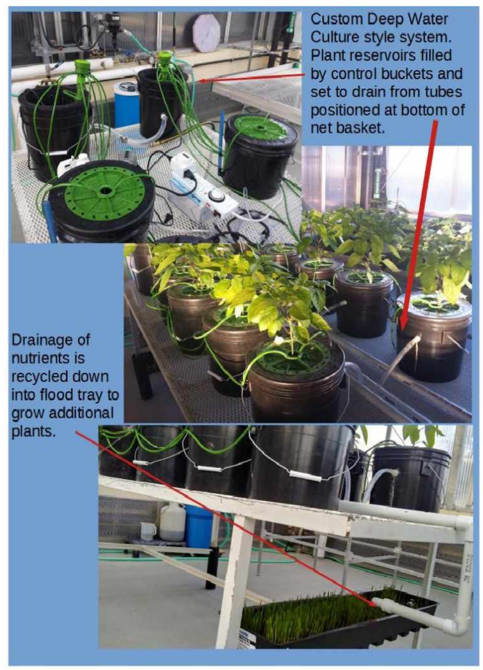


Figure 5: Prototype hydroponics system built by author at university greenhouse.

When mixing media that can create dust or nutrients that can splash, precautions should always be in place to avoid exposure to the eyes and lungs. A dust mask and safety goggles are recommended to avoid harmful exposure. Additionally, it is important to always be mindful of where electronics are located in relation to water exposure. When choosing materials to grow plants in, it is best to use materials that will not leech harmful chemicals into your growing space, such as clay or glass. Plastic labeled #1, #2, #4, or #5 have also been shown to be safe (Grant, 2018). As for the collection of ocean water to be used within a hydroponic

11 Hal Wallace, “Everything you wanted to know about LEDs but were afraid to ask” *Forbes*, 2014

system, a depth of at least three feet is ideal however it may be fine to collect from more shallow areas depending upon the area.

To create an ideal nutrient solution blend for your plants, several factors need to be considered. The pH level for most plants in a hydroponic setting ranges from 5.5 to 6.5 or slightly acidic. It is best to do research on the desired plants, as there are many that prefer an alkaline environment, and then adjust the pH accordingly. Parts per million (PPM) or total dissolved solids (TDS) should be measured regularly and help provide an idea of how saturated your solution or water is with nutrients. While this will not tell you the exact types of nutrients (these could also be pollutants) are present, it is a gauge for determining whether there is too little or too much nutrients and also when your reservoir needs to be changed. It is a good idea to measure your water before you add nutrients so that you have a base number to work with. A few hundred PPM is fine for plants starting out however as they grow larger, that number will likely increase to anywhere from 1500 to 3500. Again, background research on the type of plants you are interested in growing is recommended to get the most accurate information on what will work.

In my own experiments with salts made from Peterson Bay, I used water that was collected from approximately one to two feet under the surface. The plants seemed to consistently grow better and a fertigation analysis performed by Brookside Labs (see Figure 6) provides some insight into why that was likely the case. I did not, however, perform a microbiological or contamination test on the ocean water or the plants grown with the water. For communities interested in pursuing using ocean water

BROOKSIDE LABORATORIES, INC.

** FERTIGATION ANALYSIS REPORT **

University of Alaska, Fairbanks
P.O. Box 751081
Fairbanks, AK 99775

File Number: 80676
Date Received:11/01/2018
Date Reported:11/02/2018

Submitted By: Home Office

Lab Number : G1691
Description: PETERSON BAY

pH	7.2	
Conductivity	60151 umhos/cm	60.15 dS/m
	ppm	**mmol/L**
Chloride	18978.1	535.35
Nitrate (NO3-N)	< 1.0	< 0.07
Ammonium (NH4-N)	10.1	0.72
Sulfur as Sulfate	2403.00	25.03
Phosphorus	< 1.00	< 0.03
Calcium	428.00	10.68
Magnesium	1100.00	45.25
Potassium	427.00	10.92
Sodium	9570.00	416.27
	ppm	**umol/L**
Boron	3.95	365.37
Iron	< 0.10	< 1.79
Manganese	0.09	1.64
Copper	< 0.02	< 0.31
Zinc	0.07	1.07
Aluminum	< 0.40	< 14.81
Molybdenum	< 0.05	< 0.52
Cobalt	< 0.10	< 1.70

Figure 6: Fertigation analysis performed by Brookside Labs.

as a fertilizer, it would be best to have their ocean water tested initially to make sure it is safe. Basic water testing kits can be found at local hardware, pool, or pet stores. Various online companies offer more advanced testing kits, but for a more comprehensive water analysis, laboratories such as Brookside Labs can test for a broad range of contaminants that you may be concerned with. Another suggestion is to consult with local or Indigenous knowledge-holders, who have experience with hydroponics and food sovereignty in general, to help guide a project toward success.

Hydroponic Planning & Development

As part of this project, a hydroponic system was built for the community of Klukwan, Alaska as part of a food sovereignty project that was approved by the Chilkat Indian Village and the broader community. Their desire was to provide fresh produce throughout the community with a long-term vision of self-sufficiency in food production. A hydroponic system was specifically requested to provide locally grown greens throughout the winter months.

Klukwan is a Tlingit village located twenty-two miles north of Haines, Alaska. Tlingits historically practiced agriculture and have their own variety of potato. Klukwan has an established food garden and engages in ongoing discussions regarding food security within their community. As part of these discussions, Jennie Humphrey, an undergraduate from UAF, was allowed to conduct interviews in the village in order to learn how community members viewed their food sources and whether they felt they had access to healthy foods. Through a series of interviews, Jennie learned that there was an interest in the installation of a hydroponics system partly due to the fact that the soil quality in places where residents would like to grow is either too rocky or too clay-like.

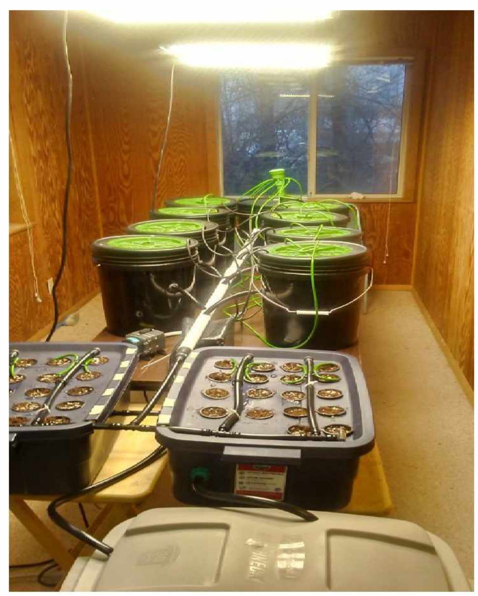


Figure 7: Klukwan's Hydroponics Garden

After learning about this situation, community members were informed about a hydroponic project that I have been working on (see Appendix C) and expressed interest in participating. In February of 2020 a trip to Klukwan was made so that the planned hydroponics system could be constructed on site, along with the community. The design was modular so that an additional expansion could be made in the future for either higher yield or automation, e.g., scheduled nutrient feedings or light on/off operations with digital timers and the drainage system was designed to recycle nutrients. The system shown (see Figure 7) took approximately five days to complete, including time it took to test the equipment to ensure it was operational.

This manual includes a list of necessary parts that I developed for Klukwan with approximated costs (see table 1). It should be noted that prices often fluctuate therefore final design decisions should not be made based on the example provided. Gathering the parts for Klukwan's hydroponic system was done through a combination of preowned parts, new parts from local sources as well as online sources such as eBay. Oftentimes, it is not possible to purchase all of the equipment from one source so it is best to use local sources whenever possible to reduce environmental impact or carbon footprint.

A post-completion follow up of Klukwan's hydroponics system was completed in the summer of 2020. The community was happy to report they were successfully growing a lot of food. It was an honor to be able to work with them to reach their desired goals. Based on these experiences, I think other communities could benefit from an ocean-based hydroponics project. Such projects would need to be customized to the specific needs of each community and ultimately the community itself would need to be involved at every stage of development. Ideally, members of the community should be involved with the construction as well, just as they were in Klukwan. Not only does this allow for the potential of creating local employment but gives those involved a deeper understanding of how all the individual parts work together, which help to reduce or eliminate dependencies with technical assistance when problems arise.

Example Parts List

Full spectrum LED lights. Other types of lights can be used, but these tend to be the most efficient in terms of power usage. Less maintenance. Typically $100-$375 each.
Fertilizer – liquid or powder form. Nutrients listed for hydroponics is ideal. Trace minerals are recommended (ocean water likely most cost effective in dehydrated form). Endomycorrhizae is optional. $20-$30 per liter of nutrient concentrations.
Coconut coir (in brick form, reconstituted with water), perlite, and recycled glass growing medium. The use of clay pebbles can bring the price down, but will not last as long between harvests. Rock wool can be used as a substitute for smaller plants. $10-$15 per brick. ~$40 per 15 liters of clay pebbles.
Exhaust and oscillating fans are optional. $25-$100 each.
Three or five gallon buckets with net pot lids at ~$15 each. These would be to grow larger plants. Tubs and trays can be used for smaller plants.
Hydroponic kits for each bucket or tub. This includes food grade vinyl lines, flow head irrigation valve, connectors, nozzles, pipes, air stones, and cable management. Larger bin or bucket to be used as nutrient reservoir.
pH up & down solution. This may or may not be needed, depending on water quality and nutrients. A digital pH/ppm tester is recommended and can range in price from $20 - $100. Measuring cup(s). Pipette.
Disposable or reusable gloves.
Reusable dust masks.
Two outdoor rated power adapters with timer switches. Digital will be more expensive, but gives more control over feeding schedules. $15-$40
Air pump ~$45 each (will need two if hybrid system is built for larger plants). For oxygenating nutrient reservoir. Submersible water pump (250 GPH), for nutrient delivery. ~$35 each
Standard water hose if needed. Anti-flood and float valves optional. Digital scale for weighing harvest. Oscillating fan. Drill w/ bits. Pruning shears. Spray bottle.
Digital Hygrometer and Thermometer. $10-$60
Note: Preowned parts may be used for a reduction in price.

Table 1

A master environmental controller can also be purchased to automatically manage things like pH, humidity and temperature, via control sensors in the area that plants will be grown (see Figure 8). High-end units allow for the environment to be remotely controlled and notifications of any problems over the internet or local area network (see Figure 9). A wireless camera can provide additional means for troubleshooting and enhance security if so desired. It must be recognized that this may not be an option for many rural communities with limited internet, thus each system will be uniquely developed to match the context they are operating in, i.e., providing options that don't require an internet connection or building a local area network that can function without an internet service provider. The following examples are viable options with costs ranging from $200 to $3,000.

Figure 8: Growtronix Base System,

https://www.growtronix.com/cart/home/1-growtronix-base-system.html

Figure 9: Hydro-X Control System,

http://nextlight.com/index.php?route=product/product&path=62_72&product_id=125

*** Seed suggestions for use in hydroponics:**
Lettuce – Dragoon, Astro, Breen, Jericho
Tomatoes – Sakura, Pozzano, Toronjina
Microgreens – Daikon Radish, Broccoli, Mung Bean, Mizuna
Kale – Toscano, Red Russian
Rainbow chard, Ruby Red
Green fennel, Prospera Compact Basil
Bell Pepper – Lunchbox Pepper Mix

https://www.johnnyseeds.com/organic/organic-vegetables/?prefn1=prod_feature_grow_cond&sz=18&start=0&prefv1=110

Results

The results from my graduate research showed that mini Bell Peppers overall had an increase in yields when supplemented with dehydrated ocean water from Peterson Bay. The usage of solar dehydrated ocean water from Alaska has so far shown that it is viable for use in hydroponics to increase harvest yields (see Figure 10 and Appendix C). As for the design of the experiments themselves, I made every effort to isolate all the variables that might give erroneous data. I used an online tool (www.randomizer.org) that helped randomize which plants would receive treatment.

In the last experiment with the help of Jennie Humphrey, she gave treatments to the wheat grass by markings on the plant containers (see Appendix B) that matched the markings on solution containers which she did not know what they were, allowing for a blinded experiment. This allowed for treatments to be made without any preferential bias. Sterilized coconut coir was used as the growth media so that treatments applied would not have interference from other preexisting nutrients or elements. Equipment was also sterilized between experiments to prevent contamination. The greenhouses the plants were grown in were also controlled environments that ensured consistency in temperature, humidity, and light.

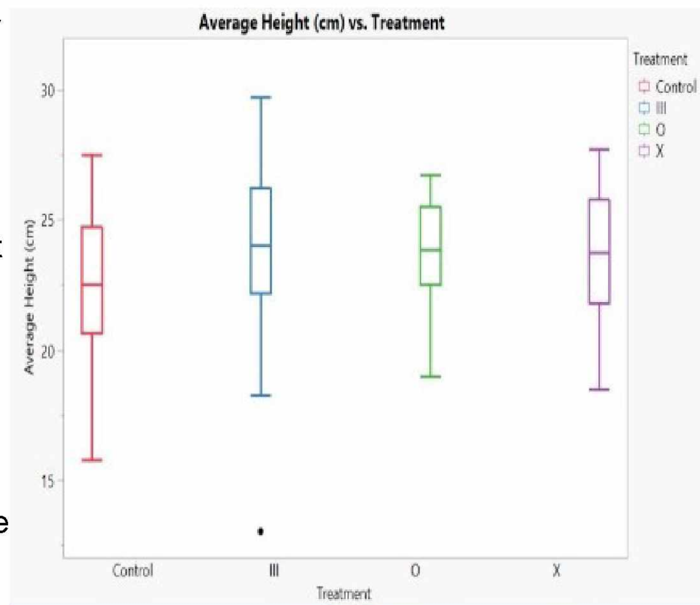


Figure 10: Four groups of thirty pairs of wheat grass, totaling 120 samples or 240 plants total, were treated with varying concentrations of ocean water ranging from ½ tsp to 1.5 tsp. (III = 1tsp, O = 1.5tsp, X= 1/2tsp) all showed a trend of increased harvest yields over control.

I hope that this guide proves to be useful for communities looking to increase their food production and exercise their sovereignty through growing their own foods, in addition to all of the other foods they harvest. As part of my previous research, a case study was conducted that reflected the importance of maintaining communal access to the ocean (Blythe, et al., 2015). The results showed that communal access to the ocean is a positive factor in communities that make salt and unfortunately this was overlooked by foreign investors in a failed shrimp farm venture that took place in Mozambique during the early 1990s.

The results from the case study are important reminders for communities, who are seeking to establish new projects or collaborating with outside entities, to carefully weigh the needs of community first and foremost and ensure members of the community are able to access the ocean. For example, a project intended to financially help the community can quickly escalate into new problems surfacing, where community members are no longer able to access the ocean, because it is set aside strictly for monetary use. As for this guide and all designs contained herein, it is intended to be free and accessible. It is also designed to be a living document, where changes will be continually made to update it to reflect the changing landscape of hydroponics with the most up-to-date information on the respective hydroponic systems and outputs. Input by others into the guide is welcome and any questions or comments may be directed to the author by email.

Appendix A

Table 9. Summary of the elemental composition of particulate matter samples from lower Cook Inlet (Cruise RP-4-Di-77A-IV, 4-16 April 1977).

Element		Average of 50 surface samples			Average of 50 samples from 5 m from the bottom		
C	(Wt.%)	4.01	±	4.0	2.72	±	2.5
N	(Wt.%)	0.65	±	0.5	0.41	±	0.4
Mg	(Wt.%)	3.54	±	0.6	3.47	±	0.9
Al	(Wt.%)	3.64	±	1.6	8.70	±	1.6
Si	(Wt.%)	31.04	±	3.4	30.20	±	4.3
K	(Wt.%)	2.15	±	0.4	2.24	±	0.4
Ca	(Wt.%)	2.20	±	0.4	2.23	±	0.3
Ti	(Wt.%)	0.55	±	0.1	0.58	±	.07
Cr	(ppm)	95	±	15	99	±	16
Mn	(ppm)	1313	±	113	1326	±	159
Fe	(Wt.%)	6.22	±	1.0	6.42	±	0.8
Ni	(ppm)	61	±	10	63	±	10
Cu	(ppm)	71	±	15	76	±	17
Zn	(ppm)	165	±	32	176	±	34
Pb	(ppm)	56	±	13	56	±	12

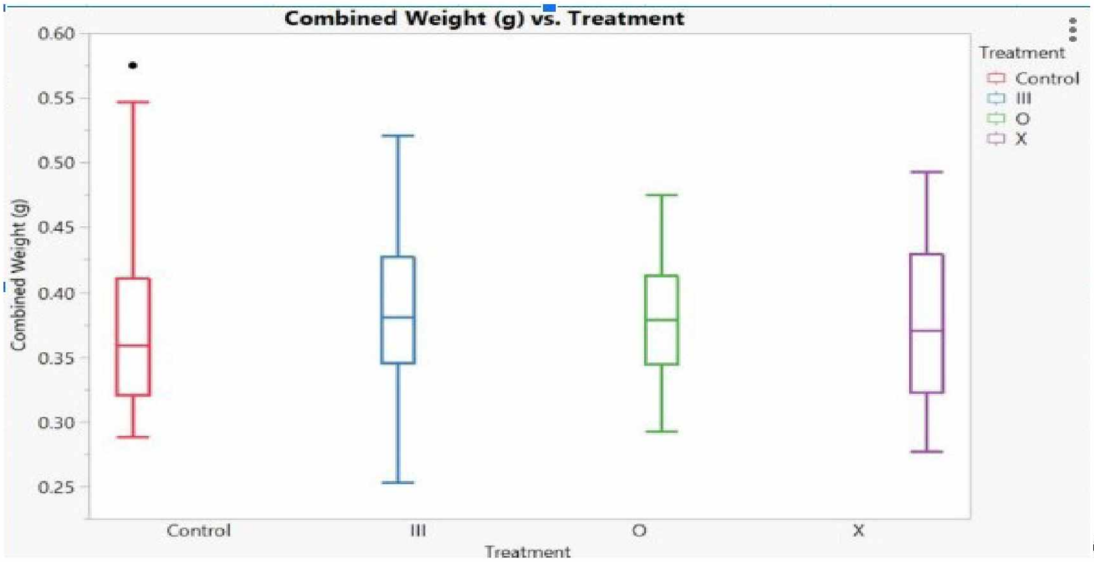
Taken from NOAA Technical Memorandum 1981

Shows elements measured in water at Kachemak Bay.

Appendix B

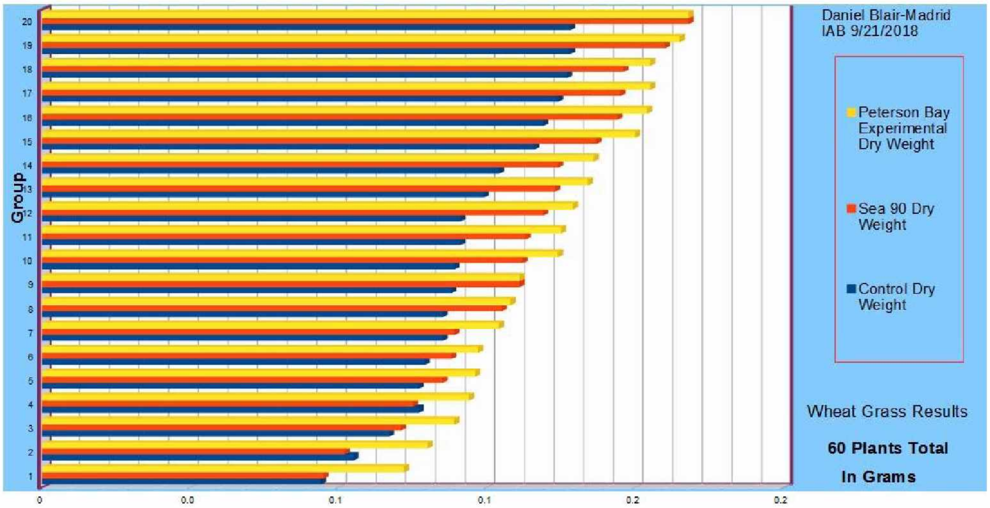
Picture of containers with wheat grass at IAB greenhouse, from previous experiment. Symbols used to identify scheduled feedings.

Appendix C

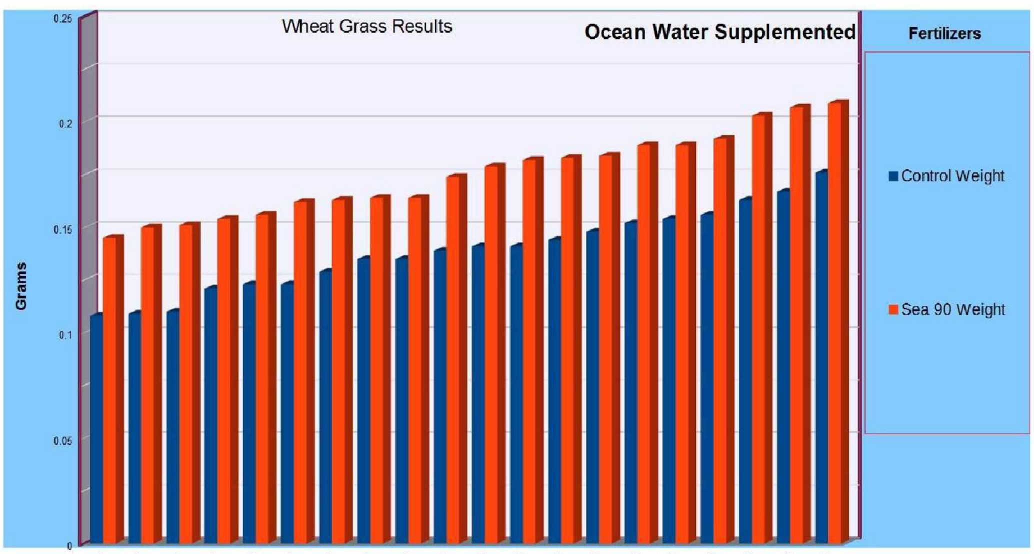


Credit: Jennie Humphrey

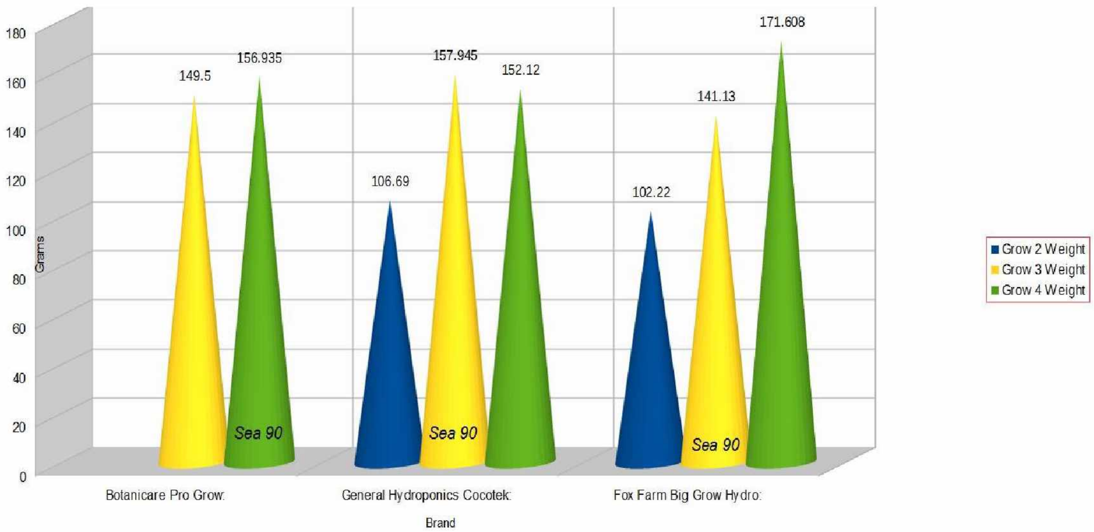
Shows averages of weights taken from last wheat grass experiment at IAB greenhouse.



Raw data from results obtained on wheat grass at IAB greenhouse. Sixty pairs of plants in the experiment actually equals 120 plants total. Each line in graph represents the combined dry weight of two plants.



Additional Sea90 results. Raw data of dry weights of harvested wheat grass material collected on 5/8/2018. Eighty plants total.



Preliminary results from older experiments with use of Sea90 solar dehydrated ocean water in conjunction with brand name fertilizers on wheat grass.

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